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HIGH POWERED ELECTRICAL POWER GENERATION BY WIND MOTORS

M. Kloss

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16. Abstract

Presents a review of wind electrical generating plants designed by Prof. E. v. Lössl. A 15 kW installation was tested in January of 1945 in Germany. Among other things it included an automatic control system for controlling variations in the wind velocity.

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HIGH POWERED ELECTRICAL POWER GENERATION BY WIND MOTORS *

Max Kloss **

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On June 14, 1944, the RAW (Reichs working group for wind power production) visited the State and Test Materials Test Facility at Koethen directed by Prof. Dr.-Ing. von Lössl. They were given a demonstration of a new type of wind wheel construction having a new type of control for the power generated by the wind wheel and input to the generator when the wind velocity is increased. The power control, as was reported earlier by the author [1], represents the main problem in the interaction between the wind wheel and the generator. The generator must be protected against overloads when the wind intensity increases, so that it is not loaded above its nominal power level specified by the heating limits. This power level can only be controlled by the wind wheel. First an attempt was made to turn the blades in order to change the angle of attack of the blade profiles with respect to the wind direction. This meant that under storm conditions, the blades would be turned into the "sail position". This type of control involves a considerable amount of effort in the construction of the mechanism.

A new type of control was suggested by E. v. Lössl. It was much simpler and he called it "umbrella running wheel". The

* From the papers of Prof. Dr.-Ing. von Lössl, deceased.
** Berlin
*** Numbers in the margin indicate pagination of original foreign text.

wheel was installed in the wake of the mass and each blade had a hinge, so that it could be turned with respect to the axis of rotation. The blades perform a uniform motion due to the installed linkages (just like an umbrella, which explains the name). During ing the visit of the RAW in Koethin, only a demonstration of the principle of the self-controlling screened wheel was given. The participants found this to be a very important contribution.

In the following year, 1945, a test installation for three phase electrical power generation to the available network was built at the request of the government. The following text was taken from the papers of E. v. Lössl.

"The self-controlled running wheel of the wind motor (Figure 1) adjusts the blade angle of attack to the wind intensity (reduces the running wheel area when the wind intensity is high), so that the generator can be sized for the reduced running wheel area. The generator must accept the entire wind wheel power and must be dimensioned for the greatest wind intensity. The wind generation installation delivers all of the produced energy to the network so that other generating stations operating in parallel and the storage units must adjust the power level to the consumers. This principle will probably be retained, because if the wind generating installations had to control the power level to the consumer, these installations would only be partially exploited in the case where large amounts of energy are offered".

In the first article entitled "High Powered Electrical Power Generation using Wind Motors", v. Lössl says the following about the machines for power production: "The asynchronous generator imposes the same rotation rate on the running wheel (except for a certain slip). In the case of the tested (for the third time) machine unit, it has a short circuit runner. Therefore

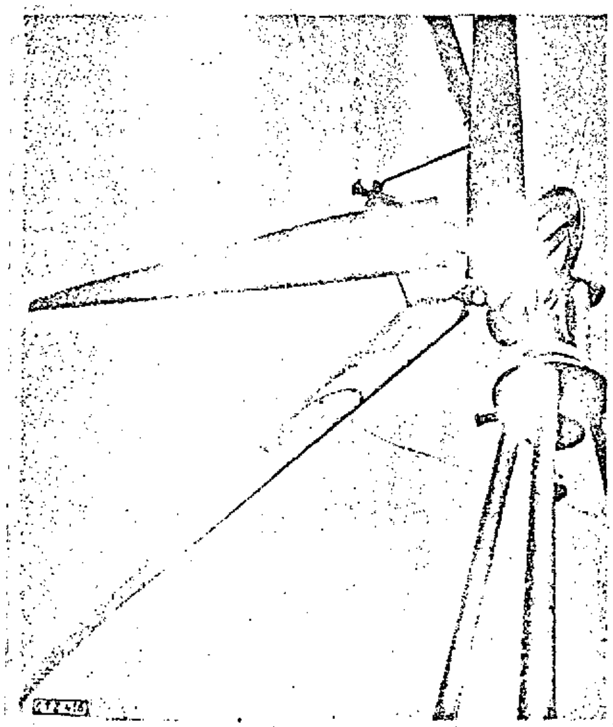

Figure 1. Screen running wheel at rest

it is very simple. Under "normal wind" conditions, the load level is small for the generator and we have $\cos \varphi = 0.2 - 0.4$. This is why at least part of the wind electrical generating stations which operate in parallel must have a compensating generator. This has the disadvantage of having a three phase and a direct current collector. However, this is simpler than the condensors suggested for improving the $\cos \varphi$.

The author does not agree with v. Lössl on this point. When v. Lössl speaks of "wind electrical generating plants operating in parallel", he apparently refers to a suggestion of the wind power generating working group (AGW', which are the successors of the earlier RAW) for supplying agricultural areas with electrical current more easily ("suggestion for including about 50 small wind electrical generating plants for supplying the MEW with electricity"). According to this suggestion, the disadvantage of an unfavorable $\cos \varphi$ of asynchronous generators is eliminated by switching condensers in parallel with the asynchronous machine. During further investigations of the control problem within the AGW in conjunction with electrical specialists from industry, it was found that completely automatic operation was a requirement because trained technicians for maintaining the machines would increase the cost per kWh to an unacceptable level. This is why compensated asynchronous machines cannot be used with their commutators. This is also true because no experience is available on the application of these machines in the exploitation of wind energy. On the other hand, the condensors do not require any maintenance and therefore do represent the simpler solution.

The design of the machine installation is stated by v. Lössl as follows: "The machine installation is driven by a vertical shaft and can be installed on the ground. When the installation is designed for series production, the generator can be installed on the tower as is usually suggested. It seems as though this question has not yet been clearly decided, as has been assumed by most designers. When the generator is on the ground, there is /202
the disadvantage of a long drive path but the advantage of easy maintenance and installation, as well as a simpler design of the tower."

The "advantage of reduced maintenance" does not overcome the objection raised above. First of all we are dealing with a first experimental version which it is desirable to make observations as easily as possible. In the report of v. Lössl he states "The following remarks apply for the auxiliary machines: the generator is turned on and off by a synchronous motor and a differential gear when the rotation rate is larger or smaller than the free wheeling rotation rate. Two shafts of the differential gear are driven by the synchronous motor and the generator. The "branch shaft" runs at the rotation rate difference and in the corresponding direction. It operates a tipping tube** through a friction coupling, which turns the magnetic current for circuit protection on and off*. The danger of "runaway" of the

* Regarding the question of automatic, frequency-dependent turn-on and turn-off of the generator and the related control questions, I would like to use this opportunity: 1. for rectifying an error which I made earlier during another presentation, and 2. in order to clarify the priority question.

1. At the beginning of 1946, the AGW appointed me as the head of the "electrotechnology working group" (AAEI). This group was concerned with planning the small scale wind generating plants mentioned above for supplying agricultural areas in parallel operation with a synchronizing three-phase network. Because of the effects of the war, the damage and the reduced capacity of the generating stations, it was no longer possible to maintain a constant frequency, which would have been the case under normal conditions. Instead, frequency fluctuations occurred, so that it was necessary to have a control which depended on frequency. At the AAEI, the firm Hein, Lehmann and Company wrote two technical reports, 78 and 79 (written by George Koenig) on equal period control" and "isodromic control with period adjustment". Since I was not clear on the project, on April 29, 1946 I asked representatives of the SSW and the AEG to design an automatic control installation in conjunction with Mr. Koenig and to present it to me. This report was given to me by Mr. Koenig after six weeks but I was still unclear on some points. In addition, H. L. and Company no longer seemed interested in wind generating plants. Mr. Koenig said he intended to form a company in the West. This meant that after this I depended on the report given to me by SSW which contained certain suggestions of Neugebauer. (continued)

** Translator's Note: could be "breakaway tube".

running wheel when the network current is turned off or when it fails is eliminated by a safety device consisting of a spring-operated two shoe brake on the generator shaft, which is released during operation by means of a servomotor. The pressurization oil for the servomotor is produced by a gear wheel pump having an auxiliary motor. When the machines are turned off, the oil pressure drops because of an equalization tap, and the brake stops the wind motor. When the network is turned on again, it automatically starts up again. In order to insure that there is no runaway at the normal net frequency (for example because of a disturbance in the generator), a centrifugal weight turns off the motor using vacuum tubes when the rotation rate is excessive, which then in turn turns on the brake.

(Continued from previous page)

Fifteen months later I wrote a report on "Problems in the Electrical Propulsion of Wind Generating Stations" for the periodical "Technology" (Die Technik), Vol. 11/1947. I based it on this SSW report in my discussion of small-scale wind generating plants for three-phase currents. Unfortunately I did not mention that the "frequency motor" was based on a suggestion of Mr. G. Koenig. I am sorry about this omission and feel it is my duty to correct this at this time.

2. "Priority question": From my report on the papers of the deceased Prof. v. Lössl, I can see that he had planned that the generator would be turned on and off depending on frequency, because he installed a synchronous motor together with a differential gear. This (third) test installation was already operational in 1945 and did supply current through the public network.

Therefore, the "priority" must undoubtedly be assigned to Dr. v. Lössl. The suggestion by G. Koenig came later on in 1946.

As far as the practical side of the problem is concerned, the automatic control as a function of frequency is no longer of any consequence. This is because the frequency can be maintained constant with a great deal of reliability because of the advances at the generating plants.

Not many improvements or simplifications were made up to the end of the war. For example, the shaft of the synchronous motor can be directly installed on the shaft of the asynchronous generator. If the direction of rotation of the synchronous motor is opposite to that of the asynchronous generator, then the housing of the former will stand still at the freewheeling rotation rate. When the asynchronous machine is loaded and acts as a generator or a motor, it will rotate in either direction with the slip rotation rate. The housing can directly operate the breakaway tube.*(Questions mentioned in the report). Instead of the hydraulic braking system, it is possible to use compressed air or a hydraulic system with air chambers. This means that the auxiliary machine will only operate intermittently to fill the pressure vessel. This is done by using a limit switch and a magnetically activated blower valve.

The second paper entitled "Wind motor for Three-phase Current Production" was written in January, 1945 and was published by the "State Test and Material Test Installation Koethen". In addition to some data already mentioned, it also contains the following important information:

Data on the test installation:

Height of the stand frame	6 m
Running wheel diameter	8 m
Running wheel rotation rate	70-73 rpm
Generator rotation rate	1500-1570 rpm
Running wheel maximum performance	15 kW
Running wheel performance at v_0 = 5 m/sec	1 kW
Running wheel circumferential velocity	30 m/sec
Running wheel u/v_o at v_0 = 5 m/sec	6

The wind motor was built as a preliminary design for large scale versions, according to the designs of Prof.-Ing. E. v. Lössl. It probably represents the first German design for three-phase current production. The current produced is transferred to the cross country network.

* Translator's Note: or "tipping tube".

Final conclusion of the author: From this it may be concluded that in principle the installation operated satisfactorily. Unfortunately no measurement results are available, in particular on the influence of varying wind intensity.

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1. Kloss, M. Direct Drive of Synchronous Generators by Large Scale Wind Generating Plants in Parallel Operation with a Synchronizing Net. Elektrotechnische Zeitscrift, Vol. 63, 1942, p. 362 and p. 388.

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